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FINAL REPORT

ONR Contract N00014-91-J-1145

Graphs and Matrices: Combinatorial Analysis,
Competitions, Covers and RanksJ. Richard Lundgren
University of Colorado at DenverJohn S. Maybee
University of Colorado at BoulderDTIC
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This report covers research from October 1, 1990 to September 30, 1993. In addition to the principal investigators, the following graduate students received partial support and contributed to the research effort: Charlie Anderson, Greg Bain, Tom Lundy, Sarah Merz, Patty McKenna, and Eric Phelps. During the time period, Mr. Anderson and Mr. Lundy received their Ph.D.s and Ms. Merz and Mr. Phelps received their M.S. degrees. Ms. Merz, Ms. McKenna, and Mr. Phelps are continuing to work toward their Ph.D.s.

A. Papers submitted to refereed journals (and not yet published):

1. "Niche Graphs and Unit Interval Graphs," to appear in *Congressus Numerantium* (C. Anderson, S. Bowser, C. Cable, and J.R. Lundgren).
2. "A Characterization of Graphs with Interval Squares," to appear in *Congressus Numerantium* (J.R. Lundgren, S. Merz, and C. Rasmussen).
3. "A Characterization of Graphs with Interval Two-Step Graphs," to appear in *Linear Algebra and Its Applications* (J.R. Lundgren, J. Maybee, S. Merz, and C. Rasmussen).
4. "Chromatic Numbers of Competition Graphs," submitted to *Linear Algebra and Its Applications* (J.R. Lundgren, S. Merz, and C. Rasmussen).
5. "Competition Inverses and a New Characterization," submitted to *Discrete Math* (J.R. Lundgren and S. Merz).
6. "Competition Graphs of Strongly Connected and Hamiltonian Digraphs," submitted to *SIAM Journal of Discrete Math* (K. Fraughnaugh, J.R. Lundgren, S. Merz, J. Maybee, and N. Pullman).



- 7-10. There are four other papers that John Maybee has submitted. John has recently retired and is away, so I don't have complete details on these papers.

B. Papers published in refereed journals:

1. "Minimum Boolean Factorizations of Tournament Codes," *Congressus Numerantium* 78 (1990), 61-70 (J.R. Lundgren and J. Maybee with G. Bain).
2. "Biclique Coverings of Regular Digraphs and Minimum Semiring Ranks of Regular Matrices," *Journal of Combinatorial Theory*, Series B, Vol 51, No. 11 (1991), 73-89 (J.R. Lundgren with D. Gregory, K. Jones, and N. Pullman).
3. "i,j Competition Graphs," *Discrete Applied Math* 32 (1991), 241-262 (J.R. Lundgren with K. Hefner, K. Jones, S. Kim, and F. Roberts).
4. "Tournament Matrices and Their Generalizations," *Linear and Multilinear Algebra* 28 (1990), 57-70 (J. Maybee and N. Pullman).
5. "Partly Zero Eigenvectors," *Linear and Multilinear Algebra* 28 (1990), 83-92 (J. Maybee with D. Olesky and P. van den Driessche).
6. "Qualitative Analysis of Schur Complements," in *Applied Geometry and Discrete Mathematics*, the Victor Klee Festschrift, Gritzman and Sturmfels, eds., American Mathematical Society and Association for Computing Machinery (1991), 359-366 (J. Maybee with C.R. Johnson).
7. "Interval Graphs with Noninterval Competition Graphs," *Congressus Numerantium* 82 (1991), 105-116 (J.R. Lundgren with C. Rasmussen).
8. "A Suggestion for New Niche Numbers for Graphs," *Congressus Numerantium* 81 (1991), 23-32 (J.R. Lundgren with C. Anderson, K. Jones, and S. Seager).
9. "Some Properties of a Class of Recursively Defined Digraphs," *Journal of Combinatorics, Information and System Sciences* 16 (1991), 29-36 (J.R. Lundgren and J. Maybee).
10. "Algebraic Multiplicity of the Eigenvalues of a Tournament Matrix," *Linear Algebra and Its Applications* 169 (1992), 170-193 (J. Maybee with D. de Caen, D. Gregory, S. Kirkland, and N. Pullman).
11. "Real Rank as a Bound for Nonnegative Integer Rank," *Journal of Combinatorial Mathematics and Combinatorial Computing* 11 (1992), 47-53 (J.R. Lundgren and J. Maybee with D. de Caen, D. Gregory, and T. Henson).

12. "Biclique Covers and Partitions of Unipathic Digraphs," *Graphs, Matrices and Designs*, Marcel Dekker, Inc. (1992) (J.R. Lundgren and J. Maybee with K. Hefner).
13. "Minimum Boolean Rank of Tournament Matrices," *Congressus Numerantium* 91 (1992), 55-62 (J.R. Lundgren and J. Maybee with G. Bain).
14. "Interval Competition Graphs of Symmetric Digraphs," *Discrete Math* 119 (1993), 113-122 (J.R. Lundgren and J. Maybee with C. Rasmussen).
15. "Two-Step Graphs of Trees," *Discrete Math* 119 (1993), 123-139 (J.R. Lundgren with C. Rasmussen).
16. "Vanishing Minor Conditions or Inverse Zero Pattern," *Linear Algebra and Its Applications* 178 (1993), 1-15 (J. Maybee with C. Johnson).
17. "Null Spaces of Matrices and Their Compounds," *Linear and Multilinear Algebra* 34 (1993), 291-300 (J. Maybee with D. Olesky, P. van der Driessche, M. Tsatsomeros).

C. Invited presentations at topical or scientific/technical society conferences:

Richard Lundgren and John Maybee gave nine invited presentations at conferences including the following: ARIDAM Conference at Rutgers University, SIAM Conference on Applied Linear Algebra in Minneapolis, Workshop on Combinatorial Matrix Theory in Minneapolis, AMS Regional Meeting in Fargo, Linear Algebra Conference in Venezuela, and Conference on Graphs and Matrices in Boulder. In addition, each of us gave several invited talks at universities including: Naval Postgraduate School, California State University at San Marcos, Rutgers University, Queen's University, and University of Victoria.

D. Contributed presentations at topical or scientific/technical society conferences:

Richard Lundgren and John Maybee gave eleven contributed presentations including the following: Southeastern International Graph Theory Conference every year, SIAM Conference on Discrete Math in Vancouver, British Combinatorial Conference, and Haifa Conference on Linear Algebra. In addition, graduate students Charlie Anderson, Tom Lundy, and Sarah Merz gave a total of seven contributed talks at these conferences and also an MAA Conference.

E. Technical reports published in non-refereed journals:

1. "Chromatic Numbers of Competition Graphs," *Naval Postgraduate School Technical Report NPS-MA-93-020* (1993) (J.R. Lundgren, S. Merz, and C. Rasmussen).

2. "A Characterization of Graphs with Interval Two-Step Graphs," *Naval Postgraduate School Technical Report NPS-MA-93-021* (1993) (J.R. Lundgren, S. Merz, J. Maybee, and C. Rasmussen).

F. Honors, awards, prizes:

1. Richard Lundgren: Outstanding Service Award, CU-Denver College of Liberal Arts and Sciences, Spring, 1991.
2. Richard Lundgren: Senior Faculty Development Award, CU-Denver University Research Council, Spring, 1992.
3. Conference on Graphs and Matrices in Boulder, Colorado in honor of John Maybee.

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